



FAA-E-2716, & Amend.-2
March 24, 1983

CHG-1 through CHG-18

U.S. Department of Transportation
Federal Aviation Administration
Specification

MODE SELECT BEACON SYSTEM (MODE S) SENSOR

FAA-E-2716 & Amend.-2
March 24, 1983

[illegible]

SPECIFICATION CHANGE NOTICE (SCN)

Date Prepared: 5/12/88

1. Originator Name and Address WEC/SDC JOINT VENTURE ATC DEPARTMENT (MS1640) FRIENDSHIP SITE BALTIMORE, MARYLAND 21203		2. <input type="checkbox"/> Proposed <input checked="" type="checkbox"/> Approved	3. Code Ident	4. Spec No. FAA-E-2716 AMENDMENT 2	5. Code Ident	6. SCN No. 12(18)
7. System Designation GROUND AIR	8. Related NCP. No. SEE ATTACHED	9. Contract No. DTFA01-85-C-00002	10. Contractual Activity ALG-322			
11. Configuration Item Nomenclature MODE SELECT BEACON SYSTEM (MODE S) SENSOR		12. Effectivity ALL				
This notice informs recipients that the specification identified by the number (and revision letter) shown in block 4 has been changed. The pages changed by this SCN (being those furnished herewith) carry the same date as this SCN. The pages of the page number and dates listed below in the summary of changed pages, combined with nonlisted pages of the original issue of the revision shown in block 4, constitute the current version of this specification.						
13. SCN No.	14. Pages Changed (Indicate Deletions)	S*	A*	15. Date		
12(18)	PAGES CHANGED AND TRANSMITTED HEREWITH 108,252,VIII-7, VIII-8 SUMMARY OF CHANGED PAGES	X		5/12/88		
1(7)	vi, 412	X		10/7/85		
2(8)	iii, 51, 54, 87, 88, 89, 90, 106, 197, 235, 239, 247, 248, 251, 252, 254, 255, 265, 267, 283, 289	X		10/14/85		
2(8)	89a, 89b, 255a, 255b		X	10/14/85		
3(9)	vi, 422	X		10/17/85		
4(10)	iv, v, vii, 7b, 104, 105, 215, 224, 238, 252, 259, 261, 363, 364, 365, 379, 381, 383, 386, 387, 388, 394, 397, 443	X		10/18/85		
4(10)	387a, 387b		X	10/18/85		
5(11)	iv, v, 373, 374, 391, 400	X		10/24/85		
6(12)	i, vii, 4, 64, 65, 443, 445, 446, 447, 448, 449, 450, 451, 452	X		1/10/86		
7(13)	120, 431, II-3	X		1/31/86		
16. Technical Concurrence <i>L. Taubenhel for</i> William G. Collins, Mode S Program Manager (Acting)				Date		

ATTACHMENT SPECIFICATION CHANGE NOTICE (SCN) CONTINUATION SHEET

Date 5/12/88
Prepared:

13. SCN No.	14. Pages Changed (Indicate Deletions)	S*	A*	15. Date
8(14)	12, 13, 14, 245, 287, 325, 326, 327, 332, 335, VIII-2, VIII-4, VIII-8, VIII-10	X		2/12/86
9(15)	iv, v, vi, 43, 137, 145, 355, 377, 387a, 398, 404, 422, 423, 424, VI-5a, VI-5b	X		5/3/88
10(16)	128, 137, 345, 387a, 387b, 399, 400, 403, 414, II-4, V-3, VI-5	X		5/5/88
11(17)	vi, 51, 53, 67, 68, 69, 73, 74, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 91, 92, 93, 110, 127, 173, 175, 267, 348, 349, 352, 360, 421	X		5/10/88
11(17)	86a, 86b, 93a, 93b		X	5/10/88
12(18)	108, 252, VIII-7, VIII-8	X		5/12/88
RELATED NCP NO.				
	<u>PSCN</u>		<u>NCP NO.</u>	
	AE		9071	
	AN		8851	
	AP		9072	

* S - Indicates Supersedes Earlier Page; A - Indicates Added Page

PC27/73056-2 11/19/85

-107b-

This page intentionally unused

An exception to this rule shall be made for a Comm-B clear (CBN or CBM equal to one) if the reply also contains a B request. In this case, the procedures of 3.4.1.6.5.3.7 shall be followed instead.

A further exception shall be made for a Comm-C clear if any uplink ELM transaction records exist for this aircraft. In this case, the state shall be changed to "C pending, normal" or "C pending, multisite", according to the value of USF.

3.4.1.6.5.3.10 Uplink ELM transaction.- A reply to an uplink ELM interrogation always has KE = '1' and a cumulative technical acknowledgment (subfield TAS, bits 17-32) in the MD field. If the uplink ELM transaction, as originally prepared by data link processing, had M segments, then the first M bits of MD are meaningful, and a '1' in one of these bits signifies transponder acceptance of the corresponding uplink message segment. Bit 17 signifies acceptance of message segment number zero, bit 18 refers to segment one, and so on up to bit 32, which refers to segment fifteen, the largest possible segment number. The transaction record for this ELM, when prepared by transaction preparation the first time the target enters the beam with this ELM pending, will have M replicas of the RC, NC and MC fields, corresponding to the M uplink message segments. Channel management notes successful delivery of message segments as follows. If a reply is accepted with KE = '1', transaction update shall obtain the length field value from the target record. Let this value be denoted by M. Transaction update shall obtain the first M bits of the TAS subfield and indicate delivery of segments accepted by the transponder. Each segment is represented in the transaction record by its RC, NC and MC fields, and the segment number is contained in the NC field, hence transaction update can indicate segment delivery in an unambiguous way. The final uplink segment is identified by its RC code of '10'. If the final segment becomes designated as delivered, transaction update shall change the RC code of an undelivered segment to '10'. The chosen segment shall be the last remaining undelivered segment in the order of their placement in the transaction record. The RC code of this segment will always have been '01'.

It is possible (because of a multisite reservation timeout) that a technical acknowledgment field will contain all zeroes even though some segments had previously been accepted. In this case, the completion indicators for those segments shall be reset so that the entire message, including the initializing segment, will be retransmitted.

Segments marked delivered are ignored by subsequent operation of roll-call scheduling. It is important to note that in case the ELM is not fully delivered in a given scan, data link processing will leave the complete original entry in the ELM list, merely copying the delivery indicators from the completed target transaction block. In the next scan, transaction preparation will prepare a new transaction record still indicating M segments, with fields for the delivered segments, completed with delivery indicators. Only when the message is fully delivered or expired will it be removed from the ELM list by data link processing.

3.4.1.6.5.3.11 Downlink ELM transactions.- A downlink ELM transaction is represented by a transaction record whose length field represents the number of downlink message segments which data link processing has requested. Let this number be denoted by L. Parts of this message may have been received in

$$\begin{aligned}\dot{\rho}_{\text{smooth}} &= \dot{\rho}_{\text{predicted}} + \beta * \epsilon \rho \\ \theta_{\text{smooth}} &= \theta_{\text{measured}} \\ \dot{\theta}_{\text{smooth}} &= \dot{\theta}_{\text{predicted}} + \beta * \epsilon \theta\end{aligned}$$

The measured values shall be obtained from the target report this scan, and the predicted values shall be obtained from the track file. The latter represent predicted values for the current scan.

The values of β used above shall depend on the magnitude of a quantity termed "track firmness", f . Track firmness is numerically equal to the number of scans since the last report. Values of β are related to track firmness in Table 3.4.6-6, except that when history firmness $g = 0$ (indicating a newly initiated track), set $\beta = 1$.

TABLE 3.4.6-6. VALUES OF β VS TRACK FIRMNESS, f

<u>Track Firmness</u>	<u>β</u>
1	1
.	.
.	.
.	.
k	1/k
.	.
.	.
K	1/K
K = 5 (3-16,1)	

After the track is smoothed, a new value of track firmness shall be determined. The transition from one firmness value to another shall depend on the present value of track firmness and whether a valid target report was received or not (i.e., what entry point was used for the program). The transition rules are listed in Table 3.4.6-7. If a report was received, the value of track history firmness g (the value of f prior to the receipt of the previous report) shall be set equal to the old firmness value, prior to calculating a new value. If a report is not received the value of g shall remain unchanged.

If a track did not have a correlating beacon or radar target report, the smoothed position and velocity shall be made equal to the predicted position and velocity. If the track is already in the last allowable firmness, the track shall be dropped.

Normal tracks shall be dropped when a firmness level of K is reached where $K = 5(3-16,1)$. For a netted Mode S sensor, Mode S tracks that enter the zenith cone (identified by TRR=1 in the surveillance file record for that track, as

TABLE 3.4.6-7. TRACK FIRMNESS TRANSITION RULES.

<u>Old Value of f</u>	<u>New Value of f, if Report Received</u>	<u>New Value of f, if Report Not Received</u>
1	f = 1	f = 2
.	.	.
.	.	.
k	f = 1	f = k + 1
.	.	.
.	.	.
K = 5(3-16,1) K _Z = 3(3-16,1)	f = 1	drop track

specified in 3.4.8.2.2) shall be dropped when a firmness level of K_Z is reached when K_Z = 3(3-16,1). For a non-netted sensor the track shall be dropped upon entering the zenith cone.

Whenever a track is dropped, a notification shall be sent to the message routing management function (3.4.8.12.5.3), for the purpose of generating a track drop message.

If the track is not at the last allowable firmness, the next firmness shall be found using Table 3.4.6-7.

3.4.6.10.4.2 Predicting a track.- Different track prediction rules apply in each of three regions defined on the basis of aircraft range and altitude. The region in which a track lies shall be determined according to the following rules: (Since ρ is stored as two-way range in Ru, aircraft altitude must be expressed similarly in the following equations, i.e., $\hat{h} = 2 \cdot 1.627 \cdot h - h_s$ where h_s = height of the sensor antenna above sea level in Ru).

If the track altitude is unknown, a pseudoaltitude \hat{h} shall be used

$$\hat{h} = 91 \text{ Ru; if } \rho \text{ meas} \geq 182 \text{ Ru}$$

$$\hat{h} = 1/2 \rho \text{ meas Ru; if } \rho \text{ meas} < 182 \text{ Ru}$$

(a) A track is in region 1 if:

$$\rho \text{ meas} > 1052 \text{ Ru; and } \hat{h} \leq \rho \text{ meas} \cdot \sqrt{2/2}$$

(b) A track is in region 2 if:

$$1052 \text{ Ru} \geq \rho \text{ meas} \geq 384 \text{ Ru; and } \hat{h} \leq \rho \text{ meas} \cdot \sqrt{2/2}$$

(c) A track is in region 3 if:

$$\rho \text{ meas} \leq 384 \text{ Ru; or } \hat{h} > \rho \text{ meas} \cdot \sqrt{2/2}$$

80.3.3.2.2 Mode S lockout.- ATCRBS/Mode S All-Call interrogations and Mode S-only All-Call interrogations (with or without site addressing) shall be selectively locked out as described in the Mode S National Standard.

80.3.3.2.3 Mode S lockout time-out.- A time-out circuit shall be used to ensure that lockout conditions do not remain in effect after contact with a Mode S sensor has been lost. Discrete address interrogations which activate the time-out circuit shall initiate lockout as specified in the Mode S National Standard. The time-out circuit shall be activated or overridden as specified in the Mode S National Standard, except that a transition from a locked out state to an unlocked state shall occur immediately upon receipt of an interrogation that does not contain a lockout command.

80.3.3.2.4 Mode S contact time-out durations.- The standard time-out circuit shall remain active for a period of T_{SC} seconds following each reply to a discrete address interrogation from a standard Mode S sensor. T_{SC} shall be independently adjustable over the range of 5 to 25 seconds with a nominal value of 18 seconds and an accuracy of ± 12.5 per cent at any setting. The means for adjusting T_{SC} need not be accessible on the control panel of the CPME.

80.3.3.3 Recovery times.

80.3.3.3.1 ATCRBS recovery times.- All CPME recovery times related to ATCRBS interrogations and replies shall be as prescribed in DOT 1010.51A.

80.3.3.3.2 Mode S recovery times.- All CPME recovery times related to Mode S interrogations and replies shall be as prescribed in the Mode S National Standard.

80.3.3.4 Reply rate limiting.

80.3.3.4.1 ATCRBS replies.- ATCRBS reply rate limiting shall operate in accordance with the provisions of paragraphs 2.7.10.1 and 2.7.10.3 of DOT 1010.51A.

80.3.3.4.2 Mode S replies.- Mode S reply rate limiting shall operate in accordance with the provisions of the Mode S National Standard.

80.3.3.5 Reply delay and jitter.- The reply delay for replies to ATCRBS and Mode S interrogations shall be in accordance with the provisions of DOT 1010.51A and the Mode S National Standard respectively, except that provision shall be made to add additional increments of delay from 0 to 2048 μ sec in steps of 16 μ sec over that specified for ATCRBS and Mode S replies. A switch shall be provided on the front panel for setting the reply delay. The selected CPME time delay shall meet the requirements of FAA Order 1010.51A and the Mode S National Standard for delay accuracy. When an additional delay is selected, the CPME shall be inactive for the selected delay time (except for asynchronous timers, e.g., lockout timers) and shall not decode further interrogations until the delayed response has been given. In no event shall the CPME reply jitter exceed 35 nsec RMS.

80.3.3.6 Transmitter characteristics.

80.3.3.6.1 Power output.- The CPME shall operate in one of two modes: low power (+15 dBm maximum output at RF port) and high power (+55 dBm output at RF port). The high power/low power select switch shall be located on the CPME front panel.

80.3.3.6.1.1 Low power mode.- When using the internal transmitter source, or an external transmitter source (80.3.5.4) set at a fixed level of +10 dBm, the CPME power output in low power mode, measured at the CPME RF port shall be variable (continuously or in 1-dB steps) over a range of -47 dBm to +15 dBm. The power setting shall be accurate within ± 2.0 dB for all settings and for all pulses of all replies. Note: when equipped with a single horn antenna, a CPME RF output of +15 dBm should be sufficient to produce a -51 dBm signal at the RF port of a sensor 0.3 nmi away (see 80.3.3.6.1.3.4).

80.3.3.6.1.2 High power mode.- When using the internal transmitter source, or an external transmitter source (80.3.5.4) set at a fixed level of +10 dBm, the CPME power output in high power mode, measured at the CPME RF port shall be variable (continuously or in 1-dB steps) over a range of +10 dBm to +55 dBm. The power setting shall be accurate to within ± 2.0 dB for all settings and for all pulse of all replies. Note: when equipped with a single horn antenna, a CPME RF output of +45 dBm should be sufficient to produce a -57.5 dBm signal at the RF port of a sensor 20 miles away (see 80.3.3.6.1.3.4).

80.3.3.6.1.3 Notes on CPME-to-sensor radio link calculations.- To determine the signal levels produced at a sensor RF port by a CPME, the following equations are used:

$$P_0 + G_1 - L + G_2 = P_i$$

where

P_0 is the power output from the CPME RF port

G_1 is the gain of the CPME antenna system including cabling

L is the free space loss

G_2 is the gain of the sensor's antenna system including cabling and rotary joint

P_i is the resulting power at the sensor's RF port.